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(71) Applicant *(for all designated States except US)*: **DISCO-VISION ASSOCIATES** [US/US]; Suite 200, 2355 Main Street, Irvine, CA 92614 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **MEYRUEIS, Patrick** [FR/FR]; 31, boulevard de l'Orangerie, F-67000 Strasbourg (FR). **EL HAFIDI, Idriss** [MA/FR]; 29, rue de la Ziegelau, F-67100 Strasbourg (FR). **GRZYMALA, Romualda** [FR/FR]; 25, boulevard d'Anvers, F-67000 Strasbourg (FR). **KIEFER, Renaud** [FR/FR]; 1, rue du Winstein, F-67800 Hoenheim (FR).

(74) Agent: **CABINET HIRSCH**; 34, rue de Bassano, F-75008 Paris (FR).

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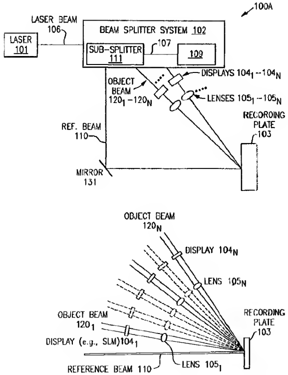

(57) Abstract: A parallel recording of diffractive storage system is provided. The recorded information is cellular for its designation. A laser beam is data modulated through a single reference beam and a plurality of object beams positioned at different angles. These object beams intersect the reference beam within a recording medium to form a plurality of data loaded pattern simultaneously.

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PARALLEL RECORDING AND READING OF DIFFRACTIVE MEMORY USING MULTIPLE OBJECT BEAMS

FIELD OF THE INVENTION

The present invention generally relates to photonics data memory devices. In particular, the present invention relates to fast access to photonics data memory devices using multiple object beams.

BACKGROUND OF THE INVENTION

There is a strong interest in high-capacity data storage systems with fast data access due to an ever-increasing demand for data storage. Limitations in the storage density of conventional magnetic memory devices have led to considerable research in the field of optical memories. Holographic memories have been proposed to supersede the optical disc (compact disc read only memories, or CD-ROMs, and digital video data, or DVDs) as a high-capacity digital storage medium. The high density and speed of holographic memory results from the use of three-dimensional recording and from the ability to simultaneously read out an entire page of data. The principal advantages of holographic memory are a higher information density, a short random-access time, and a high information transmission rate.

In holographic recording, a light beam from a coherent monochromatic source (e.g., a laser) is split into a reference beam and an object beam. The object beam is passed through a spatial light modulator (SLM) and then into a storage medium. The SLM forms a matrix of cells that modulate light intensity with grey levels. The SLM forms a matrix of shutters that represents a page of binary or grey-level data. The object beam passes through the SLM, which acts to modulate the object beam with binary information being

displayed on the SLM. The modulated object beam is directed to one point, after an appropriate beam processing, where it intersects with the reference beam after being routed by an addressing mechanism. It is also contemplated that for polychromatic holography, the polychromatic hologram may be recorded with more than one wavelength from different lasers or from the same multiline laser at the same time. In other words, the recording can be operating with several wavelengths in the holographic multiplexing process.

An optical system consisting of lenses and mirrors is used to precisely direct the optical beam encoded with the packet of data to the particular addressed area of the storage medium. Optimum use of the capacity of a thick storage medium is realized by spatial and angular multiplexing that can be enhanced by adding frequency polarization, phase multiplexing, etc. In spatial multiplexing, a set of packets is stored in the storage medium and shaped into a plane as an array of spatially separated and regularly arranged subholograms by varying the beam direction in the X-axis and Y-axis of the plane. Each subhologram is formed at a point in the storage medium with the rectangular coordinates representing the respective packet address as recorded in the storage medium. In angular multiplexing, recording is carried out by keeping the X- and Y- coordinates the same while changing the irradiation angle of the reference beam in the storage medium. By repeatedly incrementing the irradiation angle, a plurality of packets of information is recorded as a set of subholograms at the same X- and Y- spatial location.

A volume (thick) hologram requires a thick storage medium, typically a three-dimensional body made up of a material sensitive to a spatial distribution of light energy produced by interference of a coherent light beam and a reference light beam. A hologram may be recorded in a medium as a variation of absorption or phase or both. The storage material responds to incident light modulation patterns causing a change in its optical

properties. In a volume hologram, a large number of packets of data can be superimposed, so that every packet of data can be reconstructed without distortion. A volume (thick) hologram may be regarded as a superposition of three-dimensional gratings recorded in the depth of the emulsion, each satisfying the Bragg law (i.e., a volume phase grating). The grating planes in a volume hologram produce changes in refraction and/or absorption.

While holographic storage systems have not yet replaced current compact disc (CD) and digital video data (DVD) systems, many advances continue to be made which further increase the potential of storage capacity of holographic memories. This includes the use of various multiplexing techniques such as angle, wavelength, phase-code, fractal, peristrophic, and shift. However, methods for recording information in highly multiplexed volume holographic elements, and for reading them out, have not proved satisfactory in terms of throughput, crosstalk, and capacity.

Currently, one object beam and multiplexing (i.e., angular multiplexing) of a reference beam are used in holographic memory recording. Therefore, to access one packet of data, it is necessary to record and read with a specific reference angle. This is time-consuming, since the recording is done sequentially for all angles of the reference beam.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to facilitate a fuller understanding of the present invention, reference is now made to the appended drawings. These drawings should not be construed as limiting the present invention, but are intended to be exemplary only.

Figures 1A and 1B are schematic representations of an apparatus for recording multiple holograms in accordance with one embodiment of the invention.

Figure 2A is a schematic representation of the beam splitting device using a cascade of beam splitters in accordance with one embodiment of the invention.

Figure 2B is a schematic representation of a beam splitting device using a diffractive optic element in accordance with one embodiment of the invention.

Figure 3A is a schematic representation of the apparatus shown in Figure 1 for recording multiple holograms in accordance with one embodiment of the invention.

Figure 3B is a schematic representation of a recording system using a DOE as splitter in accordance with one embodiment of the invention.

Figure 4 is a schematic representation of the apparatus for reading multiple holograms in accordance with one embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention introduces the use of one reference beam and several object beams for recording and reading holographic memory. The use of multiple object beams allows parallel recording and reading at a high speed. The parallel recording and reading are achieved by moving and scanning a recording medium respectively, using one reference beam. The addressing of one point allows one to read a plurality of packets located in that one point. The use of multiple object beams in the recording system reduces the recording time by a factor of the angular multiplexing number (of the reference beam). Furthermore, it would eliminate the use of rotating mirrors to angular multiplexing of the reference beam. By the same token, the access time in reading data from the recorded memory is also reduced by a factor of the angular multiplexing number. Furthermore, it may be that just one acousto optic associated to amplification grating is needed to read all matrices, and the rotating actuator in a traditional reading system may be eliminated.

Further advantages and novel features of the present invention will become apparent to those skilled in the art from this disclosure, including the following detailed description, as well as by practice of the invention. While the invention is described below with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Those of ordinary skill in the art having access to the teachings herein will recognize additional implementations, modifications, and embodiments, as well as other fields of use, which are within the scope of the invention as disclosed and claimed herein, and with respect to which the invention could be of significant utility.

Storing/Recording Phase

Referring to FIGS. 1A and 1B, there are shown schematic representations of an apparatus for holographic recording using one reference beam and a plurality of object beams. The system 100A includes a laser 101, a beam splitter system 102, a recording medium 103, a plurality of displays 104_1 to 104_N (where N is a positive integer), and a plurality of lenses 105_1 to 105_N.

The laser 101 provides a laser beam 106 (i.e., coherent light beam) to the beam splitter system 102. In one embodiment, the laser 101 is a YAG doubled laser, i.e., a solid state laser. A rod of YAG material emits laser light in the infrared to the laser 101. The laser light associates with a nonlinear crystal that produces double the YAG-emitted light frequency. The laser beam 106 emanating from laser 101 is split into a reference beam 110 and a main object beam 107 (shown in Figures 2A and 2B) by the sub-splitter 111, which are then split into a plurality of object beams 120_1 to 120_N. The main object beam 107 is split into a plurality of object beams 120_1 to 120_N by a multiple beam splitter 109. The multiple beam splitter 109 may be internal or external to the beam splitter system 102. In one embodiment, the multiple beam splitter 109 is a diffractive optic element (DOE) and in another embodiment the multiple beam splitter 109 includes a cascade of beam splitters 130_1 to 130_{N-1}, as shown in FIG. 2A, and a mirror 131.

Referring to FIG. 2A, there is shown a schematic representation of a multiple beam splitter 109 as a cascade of beam splitters according to one embodiment of the invention. The beam device 109 includes a plurality of cascade beam splitters 130_1 to 130_{N-1} and the mirror 131. The main object beam 109, split from the laser beam 107, is then split into the plurality of object beams 120_1 to 120_N by the multiple beam splitter 109 (i.e., cascade of beam splitters and mirror). The beam splitting power is controlled to have the same beam

intensities routed to the SLMs set. The light-split intensity depends on the reflectivity of the coated layer on the splitter substrate. In one embodiment, every object beam has the same photonic power so that every SLM can receive approximately the same light power. In other words, this provides basically the same splitted power to each beam addressing the set of SLMs. Every recorded plate recording substrate with the same intensity on each of the charge-coupled devices (CCDs), every recorded plate provides a set of packets with the same energy due to the same-recorded effect on the recording substrate.

As described above, the splitting may be done by means of diffractive grating or by a cascade of beam splitters. The high-density main object beam 107 is equally split on every SLM. This splitting provides every SLM with an equal light power. After the data is loaded by every SLM on each split laser beam, they are focused by the set of lenses 105_1 to 105_N onto the same point on the recorded substrate of the recording medium 103.

In the case where the energy level of each object beam does not match one another, adjusting the sensitivity of each SLM device is possible. Furthermore, if the energy level of each beam is different, optical attenuators may be selected to adapt jointly to the energy on the beam and the sensitivity of the SLMs. One SLM in the plurality of SLMs is a "master" SLM for the other SLMs. The light power is adjusted on the reference of this master light by using attenuators. Every attenuator is adapted for different beams. The optical density of the attenuator is adapted to the power available on the SLMs. For example, if one SLM receives energy differently from its neighbor SLM, an attenuator is used to adjust the energy on the neighbor SLM so that the intensity of the image supporting the recorded packet is the same. This provides uniform intensity of the packet of data read.

Referring to FIG. 2B, there is shown a schematic representation of the diffractive optical element (DOE) as the multiple beam splitter 109 according to one embodiment of

the invention. The main object beam 107 is split from the laser beam 106 and is emitted to the DOE 109. The DOE 109 produces a multitude of diffracted beams (i.e., object beams 120_1 to 120_N). These diffractive beams are routed to arranged mirrors (not shown) and to the SLMs set individually.

The recording medium 103 has a plurality of cells to hold the recorded information. The recording medium 103 is a plate holographic memory device that contains information stored during a phase of storing information. The recording (i.e., storage) medium is typically a three-dimensional body made up of a material sensitive to a spatial distribution of light energy produced by interference of the object beams 120_1 to 120_N and the reference light beam 110. A hologram may be recorded in a medium as a variation of absorption or phase or both. The storage material responds to incident light modulated patterns causing the change in its optical properties. In a volume (thick) hologram, a large number of packets of data can be superimposed, so that every packet of data can be reconstructed without distortion. A volume hologram may be regarded as a superposition of three-dimensional gratings recorded in the depth of the layer of the recording material, each satisfying the Bragg law (i.e., a volume phase grating). The grating modulation in a volume hologram produces change in refraction and/or absorption. The recording medium 103 may be arranged in the form of a flat layer, herein referred to as a matrix. Each of a plurality of points on the matrix is defined by its rectilinear coordinates (X,Y). A point in physical space, defined by its rectilinear coordinates, contains a plurality of packets.

In one embodiment, the recording medium 103 is constructed of organic material, such as a polypeptide material, and made in accordance with the techniques described in the co-pending patent application entitled "Photonics Data Storage System Using a Polypeptide Material and Method for Making Same," Serial No. PCT/FR01/02386, which is herein incorporated by reference.

The plurality of object beams 120_1 to 120_N, pass through the plurality of displays (e.g., SLMs) 104_1 to 104_N and then into the storage medium 103. In other words, each object beam is loaded with data by its corresponding display, and that display is illuminated by the main object beam 107 after splitting by the multiple beam splitter 109. The object beams 120_1 to 120_N, are positioned at different angles. Each display of the plurality of displays 104_1 to 104_N forms a matrix of shutters that represents a packet of binary data. The object beams 120_1 to 120_N may be filtered and collimated. The object beams 120_1 to 120_N are directed to the displays 104_1 to 104_N, which display images to be recorded. The object beams 120_1 to 120_N become modulated by the information to be recorded by means of reflection off or transmission through the displays 104_1 to 104_N.

The displays 104_1 to 104_N may be any devices for displaying data packets in a system, such as spatial light modulators (SLMs) or liquid crystal light valves (LCLVs). In one embodiment, the plurality of bits represented on the display screen of the displays 104_1 to 104_N is presented as a two-dimensional pattern of transparent and opaque pixels (i.e., data packet). The data packet displayed is derived from any source such as a computer program, the Internet, and so forth. In an Internet storage application, the packets displayed may be formatted similarly to the packets of the Internet.

The reference laser beam 110 interferes coherently with the object beams 120_1 to 120_N to form the interference patterns or holograms, which are stored in the recording medium 103 due to the perturbation in the refractive index. Thus, each hologram is stored at a unique angle of the object beams 120_1 to 120_N. The separation between the various holograms stored within the same volume relies on the cross talk separation and angular tolerancing, in order to allow its retrieval only for a defined angle value.

As stated above, the object beams 120_1 to 120_N pass through the displays 104_1 to 104_N, which act to modulate the object beams 120_1 to 120_N with the binary information.

The object beams 120_1 to 120_N are then directed to a defined point on the recording medium 103 where they intersect with the reference beam to create a plurality of holograms representing packets of data. The plurality of lenses 105_1 to 105_N is used to converge the modulated object beams 120_1 to 120_N and to focus the beams to the recording medium 103. In other words, the modulated beams 120_1 to 120_N become reduced by means of suitable lenses 105_1 to 105_N so that the point of convergence of the modulated object beams 120_1 to 120_N lies slightly beyond the recording medium 103. The object beams 120_1 to 120_N are positioned at different angles so that plurality of data packets is recorded at one point of the recording medium 103. The different angle is calculated or adjusted to a position to avoid crosstalk between two output neighboring beams.

Referring to FIG. 3A, there is shown a more detailed schematic representation of the apparatus shown in FIG. 1 for holographic recording using multiple object beams. The system 300 includes the single reference beam 110, the set of several object beams 120_1 to 120_N, and the recording medium 103. The reference beam 110 and the object beams 120_1 to 120_N intersect to form patterns to be recorded on the recording medium 103 at an X,Y location. In other words, for one X,Y location, the recording is done by one reference beam and several object beams intersect. Each object beam is oriented according to a specific angle so that it can be focused on one point in the recording medium 103. The object beams 120_1 to 120_N are positioned at different angles, similar to the way the reference beam is angularly multiplexed in the previous recording system using angular multiplexing for the reference beam. All the multiplexed object beams 120_1 to 120_N are recorded simultaneously at one point by using one reference beam 110. To go to the next recording point, the recording medium is moved in X, Y direction by a moving system (not shown). This is the spatial multiplexing that is carried out by sequentially changing the

rectilinear coordinates. The plurality of object beams 120_1 to 120_N focus on the recording medium 103 so that N number of separate images are recorded at a unique position in a plane defined by its coordinates (X,Y).

Referring to FIG. 3B, there is shown a recording system 300B using a DOE as splitter to generate multiple diffractive beams in accordance with one embodiment of the invention. The system 300 includes the laser source 101, the beam splitter system 102, the DOE 109, a plurality of mirrors 301_1 to 301_N, a plurality of expanding and collimating beam devices 305_1 to 305_N, the plurality of displays 104_1 to 104_N, the plurality of focusing lenses 105_1 to 105_N, and the recording plate 103.

The functions and characteristics of the laser source 101, the beam splitter 102, the displays 104_1 to 104_N, the focusing lenses 105_1 to 105_N, and the recording plate 103 are already described above. The DOE 109 produces a plurality of multitude of diffracted beams 304_1 to 304_N. The plurality of mirrors 301_1 to 301_N directs the beams to the plurality of corresponding expanding and collimating beam devices 305_1 to 305_N for expanding and collimating the multiple diffracted beams. The expanded and collimated beams pass through the displays 104_1 to 104_N to become a plurality of object beams which intersect with the reference 110 at a point on the recording plate 103 to form a plurality of data packets.

Reading Phase

Referring to FIG. 4, there is shown a schematic representation of an apparatus for holographic reading using one reference beam to read a plurality of packets simultaneously. The system 400 includes a laser 401 (e.g., laser 101), the recording medium 103, a plurality of image sensors (i.e., phototransistor devices, CCDs) 405_1 to 405_N, and a plurality of lenses 406_1 to 406_N. The laser 401 emits a coherent light beam

410 (i.e., reading/reference beam) to the recording medium 103. The reference beam 410 may be the same as the reference beam 110. The recording medium 103 has a plurality of cells that hold the recorded information

Retrieving the recorded/stored information from the diffractive memory device 103 requires the use of the reference beam 410 (i.e., read beam) whose characteristics correspond to those employed for writing (i.e., reference beam 110) or for storage. The reference beam 410 induces diffraction in the polypeptide layer due to perturbation in the refractive index corresponding to the characteristics of the beams interference, thereby creating a plurality of stored packets related to modulated beams 430_1 to 430_N.

The reference beam 410 is positioned in order to access a plurality of data packets contained at a defined point (X,Y) on the matrix in the recording medium 103. The reading procedure is similar to the writing or recording procedure. However, the reading procedure may be carried out with a greater degree of tolerance than the recording procedure. It is possible to use a very compact laser source of a solid-state type for the reading process because the laser power necessary for reading is much lower than the one for recording.

The plurality of data packets in the diffractive memory device 103 are reconstructed simultaneously by shining the reference beam 410 at the same location in which the data packets were recorded. The reference beam 410 diffracted by the diffractive memory device 103 forms the reconstruction, which is detected by the plurality of arrays of image sensors 405_1 to 405_N. The reference beam 410 is configured to address the plurality of packets at different locations in the diffractive memory device 103. The plurality of lenses 406_1 to 406_N are positioned at different angles to focus output beams produced by the diffraction of the reference beam 410 onto the image sensors 405_1 to 405_N. In one embodiment, the reference beam 410 is positioned perpendicular to the recording plate for recording. Therefore, there is no angular deflection in parallel reading. The read beam

is diffracted for the reading into plurality of channels simultaneously. Every channel is materialized by an output beam loaded with a data packet that is positioned with a programmed angular value. This angular value is fitted to angular positioning of the beam used to record data from the displays 104_1 to 104_N. The X,Y scanning is performed to proceed from one point to the next for the next reading of information on the diffractive memory device 103 diffracted and from there the output packets are focused.

The laser reference beam (i.e., reading beam) 410 is shaped and directed onto the recorded medium 103 and from there focused by imaging lenses 406_1 to 406_N onto image sensors (e.g., CCD cameras) 405_1 to 405_N, each of which has a number of pixels adapted to the desired resolution. The digital output of the image sensors 405_1 to 405_N is further processed by a computer (not shown).

The reference beam 410 (i.e., read beam) emanates from the low-power laser 401. Typically the reference beam is less than 5 mW. The laser 401 may be a helium-neon or semiconductor-type laser. The reference beam 410 may be modulated by means of one or more transformation activators (not shown) lying in the optical path of the beam for reading data recorded in a plurality of points.

The present invention is not to be limited in scope by the specific embodiments described herein. Indeed, this application is intended to cover any modifications of the present invention, in addition to those described herein, and the present invention is not confined to the details which have been set forth. Thus, the scope of the invention should be determined by the appended claims and their legal equivalents, rather than by the examples given.

CLAIMS

What is claimed is:

1. An apparatus comprising:

a recording medium for recording information designated to a cell;

a laser for transmitting a reference beam to the recording medium; and

a multiple beam splitter for transmitting a plurality of object beams to the recording medium at different angles, the object beams intersecting the reference beam within the recording medium to form a plurality of patterns.

2. The apparatus according to claim 1 further comprising a plurality of displays for displaying the information to be recorded, the object beams being modulated by reflection off or transmission through the displays.

3. The apparatus according to claim 2 further comprising a plurality of lenses for converging the modulated object beams and focusing the modulated beams to a point on the recording medium.

4. The apparatus according to claim 1 wherein the recording medium is a holographic plate memory device.

5. The apparatus according to claim 2 wherein the displays are spatial light modulators (SLMs).

6. The apparatus according to claim 1 wherein the cell includes the plurality of interference patterns.

7. The apparatus according to claim 1 wherein the recording medium is made of polypeptide material.

8. An apparatus comprising:

a recording medium for recording information designated to a cell;

a laser for transmitting a reference beam to the recording medium; and

a multiple beam splitter for transmitting a plurality of object beams to the recording medium at different angles, the object beams simultaneously intersecting the reference beam within the recording medium to form a plurality of patterns.

9. An apparatus comprising:

a recording medium for recording information designated to a cell;

a laser for transmitting a reference beam to the recording medium;

a multiple beam splitter for transmitting a plurality of object beams to the recording medium at different angles, the object beams intersecting the reference beam within the recording medium to form a plurality of patterns; and

a plurality of displays for displaying the information to be recorded, the object beams being modulated by reflection off or transmission through the displays.

10. An apparatus comprising:

a recording medium for recording information designated to a cell;

a beam splitter system for transmitting a reference beam to the recording medium;

an multiple beam splitter for simultaneously transmitting a plurality of object beams to the recording medium at different angles, the object beams intersecting the reference

beam within the recording medium to form a plurality of patterns; and

a plurality of displays for displaying the information to be recorded, the object beams being modulated by reflection off or transmission through the displays.

11. A method comprising:

transmitting a reference beam to a recording medium;

positioning a plurality of object beams at different angles;

transmitting a plurality of object beams to the recording medium; and

intersecting the reference beam and the plurality of object beams within a cell in the recording medium to form a plurality of patterns.

12. The method according to claim 11 further comprising:

displaying information to be recorded on a plurality of displays; and

modulating the object beams by reflecting off or transmitting the information through the displays.

13. The method according to claim 12 further comprising converging the modulated object beams.

14. The method according to claim 13 wherein the recording medium is a holographic plate memory device.

15. The method according to claim 12 wherein the displays are spatial light modulators.

16. The method according to claim 11 wherein the data loaded on the object beams are stored through the plurality of interference patterns.

17. The method according to claim 11 wherein the recording medium is made of polypeptide material.

18. A method comprising:

transmitting a reference beam to a recording medium;

arranging a plurality of object beams at different angles;

simultaneously transmitting a plurality of object beams to the medium; and

intersecting the reference beam and the plurality of object beams within a cell in the recording medium to form a plurality of patterns.

19. A method comprising:

transmitting a reference beam to a recording medium;

arranging a plurality of object beams at different angles;

transmitting a plurality of object beams to the medium;

intersecting the reference beam and the plurality of object beams within a cell in the recording medium to form a plurality of patterns; and

displaying information to be recorded on a plurality of displays.

20. The method according to claim 19 further comprising modulating the object beams by reflecting off or transmitting the information through the displays.

21. The method according to claim 20 further comprising converging the

modulated object beams.

22. An apparatus comprising:

a memory device including a cell for containing recorded information;

a beam splitter system for transmitting a reference beam to the memory device to read the recorded information; and

a multiple beam splitter for transmitting a plurality of object beams to the recording medium at different angles, the object beams intersecting the reference beam within the recording medium to form a plurality of patterns.

23. The apparatus of claim 22 wherein the multiple beam splitter is a diffractive optic element.

24. The apparatus of claim 22 wherein the multiple beam splitter is a cascade of beam splitters.

25. An apparatus comprising:

a memory device having a plurality of.patterns;

a beam splitter system for transmitting a reference beam to the memory device to read output data packets stored through the plurality of patterns;

a plurality of lenses for forming images produced by diffraction of the patterns; and

means for converting the images into electrical signals.

26. The apparatus according to claim 23 wherein means of converting are a

plurality of CCDs (charge-coupled devices).

27. The apparatus according to claim 24 further comprising a computer for processing and analyzing the electrical signals.

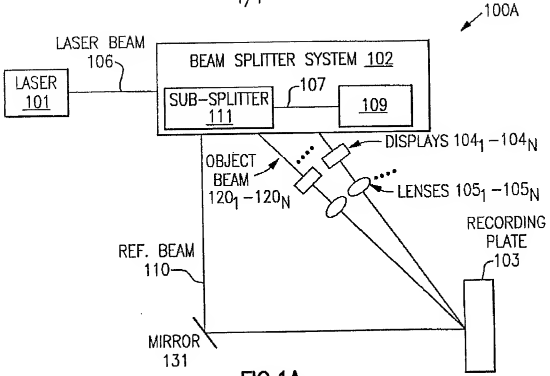
100A
LASER BEAM
106
LASER
101
BEAM SPLITTER SYSTEM 102
107
SUB-SPLITTER
111
109
DISPLAYS 104$_1$ –104$_N$
OBJECT
BEAM
120$_1$ –120$_N$
LENSES 105$_1$ –105$_N$
RECORDING
PLATE
103
REF. BEAM
110
MIRROR
131

FIG.1A

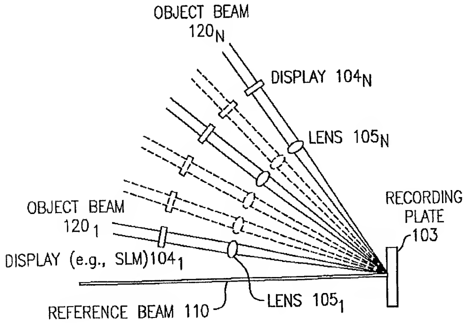
OBJECT BEAM
120$_N$
DISPLAY 104$_N$
LENS 105$_N$
RECORDING
PLATE
103
OBJECT BEAM
120$_1$
DISPLAY (e.g., SLM)104$_1$
REFERENCE BEAM 110
LENS 105$_1$

FIG.1B

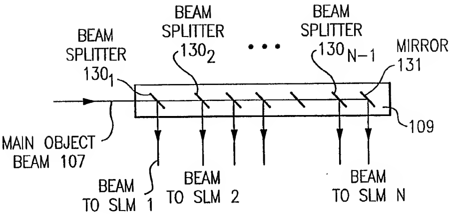

FIG.2A

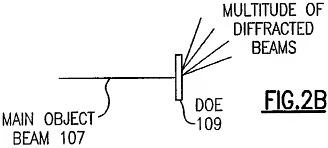

FIG.2B

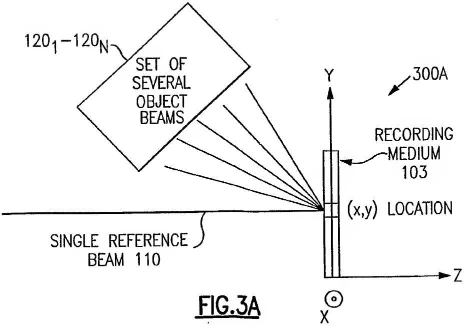

FIG.3A

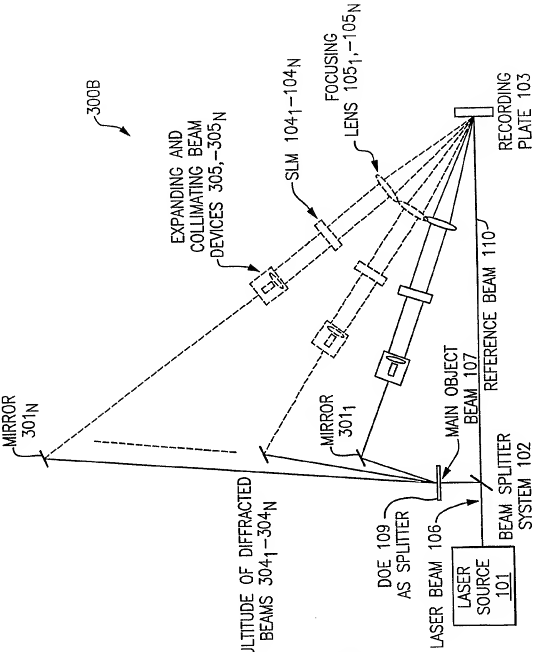
300B
EXPANDING AND COLLIMATING BEAM DEVICES 305_1–305_N
SLM 104_1–104_N
FOCUSING LENS 105_1–105_N
RECORDING PLATE 103
MIRROR 301_N
MIRROR 301_1
MAIN OBJECT BEAM 107
REFERENCE BEAM 110
MULTITUDE OF DIFFRACTED BEAMS 304_1–304_N
DOE 109 AS SPLITTER
LASER BEAM 106
BEAM SPLITTER SYSTEM 102
LASER SOURCE 101

FIG.3B

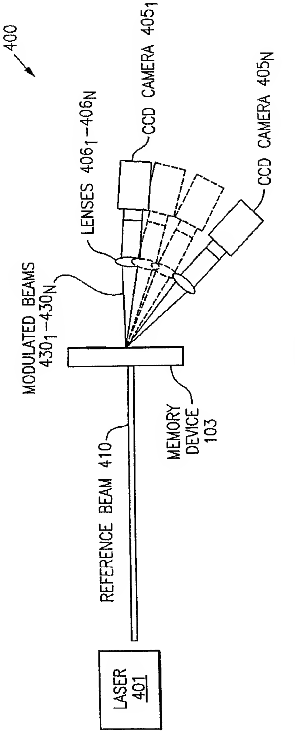
400
CCD CAMERA 405_1
LENSES 406_1–406_N
CCD CAMERA 405_N
MODULATED BEAMS 430_1–430_N
MEMORY DEVICE 103
REFERENCE BEAM 410
LASER 401

FIG.4

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 02/05445

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G11B7/0065 G11C13/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G11B G11C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 476 536 A (NIPPON TELEGRAPH & TELEPHONE) 25 March 1992 (1992-03-25)	1-6, 8-16, 18-23, 25-27
Y	page 6, line 49 -page 9, line 33; figures 3,4 page 9, line 34 -page 11, line 16; figure 5	7,17
Y	WO 00 30084 A (CAMBRIDGE SCIENT INC) 25 May 2000 (2000-05-25) the whole document	7,17
A	US 4 175 823 A (KIEMLE HORST ET AL) 27 November 1979 (1979-11-27) the whole document	1,8-11, 18,19, 22,25

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 December 2002	27/12/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Holubov, C

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 02/05445

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 213 193 A (REID DOUGLAS C J ET AL) 15 July 1980 (1980-07-15) the whole document -----	1,8-11, 18,19, 22,25

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 25-27 (partial search)

Present claims 25-27 relate to a large number of apparatus. Support within the meaning of Article 6 PCT and disclosure within the meaning of Article 5 PCT is to be found for only a small proportion of the apparatus claimed. These claims so lack support, and the application so lacks disclosure, that a meaningful search over the whole of the claimed scope is impossible.
Consequently the search has been carried out for those parts of the claimed subject-matter which appears to be supported and disclosed, namely those parts relating to apparatus comprising a holographic memory device having a plurality data packets stored as a plurality of diffractive patterns, a beam splitter system adapted to transmit a reference beam to the memory device to read simultaneously a plurality of output data packets, a plurality of lenses at different angles for simultaneously forming images produced by the diffaction of the patterns on to a plurality of means for converting the images into electrical signals.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

INTERNATIONAL SEARCH REPORT	International application No. PCT/EP 02/05445

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [ ] Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. [X] Claims Nos.: 25-27 (partial search)
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 02/05445

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0476536 A	25-03-1992	CA 2051193 A1	15-03-1992
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